What is claimed is:

1. A reset circuit for an integrating amplifier, including:

first comparator circuitry having a first input terminal, a second input terminal and a first output terminal;

a first conductive path adapted to couple the first input terminal to a feedback loop of an integrating amplifier between an integrator output of the integrating amplifier and an integrating capacitor along the feedback loop, whereby a comparator input voltage at the first input terminal is changed in a predetermined first direction and in proportion to an amplitude of an incoming current during integration of the incoming current;

a substantially stable voltage source for biasing the second input terminal at a first threshold voltage level selected to determine one end of an operating range for integration, wherein the first comparator input voltage, when in said range and when so changed during integration, approaches the first threshold voltage level; and

a second conductive path coupling the first output terminal to the feedback loop;

wherein the first comparator circuitry is adapted, in response to detecting movement of the comparator input voltage out of the operating range beyond the first threshold voltage level, to generate a predetermined first comparator output voltage level at the first output terminal and to apply the comparator output voltage level to the feedback loop via the second conductive path, thereby to drive the comparator input voltage in a second direction opposite said first direction to a point within the operating range for further integration of the incoming current.

2. The circuit of claim 1 wherein:

the first comparator circuitry further is adapted to stop the application of the first comparator output voltage level to the feedback loop, responsive to detecting movement of the comparator input voltage, during said application, in the second direction beyond the first threshold voltage level and into the operating range.

3. The circuit of claim 1 further including:

an RC network along the first conductive path for interposing a time delay between a given change in the integrator output the voltage and a corresponding change in the comparator input voltage at the first input terminal.

4. The circuit of claim 1 further including:

second comparator circuitry having a third input terminal, a fourth input terminal and a second output terminal, wherein the third input terminal is coupled to receive the comparator input voltage;

a substantially stable second voltage source for biasing the fourth input terminal at a second threshold voltage level selected to determine a second and opposite end of the operating range, wherein the comparator input voltage, when in the operating range and when driven in said opposite direction, moves toward the second threshold voltage level; and

a third conductive path adapted to couple the second output terminal to the feedback loop;

wherein the second comparator circuitry is adapted, in response to detecting movement of the comparator input voltage in the second direction out of the operating range beyond the second threshold voltage level, to generate a predetermined second comparator output voltage level at the second output terminal and to apply the second comparator output voltage level to the feedback loop via the third conductive path, thereby to drive the comparator input voltage in the first direction to a point within the operating range for further integration of the incoming current.

5. The circuit of claim 1 wherein:

the comparator input voltage, when in the operating range, is higher than the first threshold voltage level, and is reduced during integration of the incoming current.

6. The circuit of claim 5 wherein:

the substantially stable first comparator output voltage level is a high voltage selected to rapidly charge the integrating capacitor.

7. The circuit of claim 6 wherein:

the first comparator circuitry is adapted to alternatively generate said high voltage and a substantially stable low voltage, wherein applying the first comparator output voltage to the feedback loop consists essentially of switching from the low voltage to the high voltage, and stopping the application to the feedback loop consists essentially of switching from the high voltage to the low voltage.

8. The circuit of Claim 7 further including:

power control circuitry having a fifth input terminal coupled to the first output terminal, a third output terminal, and a fourth conductive path adapted to couple the third output terminal to an input of the integrating amplifier to provide power to the integrating amplifier;

wherein the power control circuitry is adapted to generate a substantially stable high voltage during integration, and to switch from the high voltage to a substantially stable low voltage in response to receiving the high voltage from first comparator circuitry, thereby to shut off power to the integrating amplifier.

9. The circuit of claim 6 further including:

a diode along the second conductive path, oriented with its forward direction coincident with current flow from the first output terminal to the feedback loop.

10. The circuit of claim 6 further including:

limiting circuitry coupled to the second conductive path to prevent excess charging of the integrating capacitor.

11. The circuit of claim 10 wherein:

the limiting circuit includes a limiting capacitor coupled to be charged simultaneously with charging of the integrating capacitor, and a diode biased to a substantially stable limiting voltage level.

12. The circuit of claim 4 wherein:

the comparator input voltage, when in the operating range, is higher than the first threshold voltage level, and lower than the second threshold voltage level, and is reduced during integration of the incoming current.

13. The circuit of claim 12 wherein:

the first comparator circuitry is adapted to alternatively generate a substantially stable high voltage and a substantially stable low voltage at the first output terminal, and generating the first comparator output voltage level consists essentially of switching from the low voltage to the high voltage to rapidly charge the integrating capacitor.

14. The circuit of claim 13 wherein:

the second comparator circuitry is adapted to alternatively generate a substantially stable high voltage and a substantially stable low voltage at the second output terminal, and generating the second comparator output level consists essentially of switching from the high voltage to the low voltage to rapidly discharge the integrating capacitor.

15. The circuit of claim 14 further including:

power control circuitry having a fifth input terminal coupled to the first output terminal, a third output terminal, and a fourth conductive path adapted to couple the third output terminal to an input of the integrating amplifier to provide power to the integrating amplifier;

wherein the power control circuitry is adapted to generate a substantially stable high voltage during integration, and to switch from the high voltage to a substantially stable low voltage in response to receiving the high voltage from the first comparator circuitry, thereby to shut off power to the integrating amplifier.

16. The circuit of claim 15 wherein:

the power control circuit comprises an operational amplifier with a positive input terminal biased at a substantially stable voltage and a negative input terminal coupled to the first output terminal, and each of the first and second comparator circuitry comprises an operational amplifier with resistive feedback receiving the first comparator input voltage at a negative input terminal.

17. A process for measuring an electrical current, including:

providing an electrical current to an input terminal of an operational amplifier with a feedback loop including an integrating capacitor;

integrating the electrical current to generate, at an integrator output, an integrator output voltage that changes in a predetermined first direction and at a rate determined by a level of the electrical current;

detecting a voltage along the feedback loop between the integrator output and the integrating capacitor to provide a condition-monitoring voltage that undergoes changes determined by the electrical current and corresponding to changes in the integrator output voltage;

setting a substantially stable first threshold voltage to determine a first end of an operating range of the condition-monitoring voltage, over which the electrical current is integrated;

comparing the condition-monitoring voltage with the first threshold voltage; and

in response to detecting movement of the condition-monitoring voltage in the first direction beyond the first threshold voltage and out of the operating range, applying a first reset signal to the feedback loop to drive the condition-monitoring voltage in a second direction opposite the first direction to a point within the operating range for further integration of the electrical current.

18. The process of claim 17 further including:

continuing to compare the condition monitoring voltage with the first threshold voltage after applying the first reset signal; and

responsive to detecting movement of the condition-monitoring voltage in the second direction beyond the first threshold voltage and into the operating range, discontinuing application of the first reset signal.

19. The process of claim 17 further including:

interposing a time delay between the integrator output voltage and the condition-monitoring voltage.

20. The process of claim 17 wherein:

the condition-monitoring voltage when in the operating range is greater than the first threshold voltage, and is reduced during integration of the electrical current.

21. The process of claim 20 further including:

alternatively applying a substantially stable high voltage and a substantially stable low voltage to the feedback loop, wherein said applying the first reset signal comprises switching from the low voltage to the high voltage to rapidly charge the integrating capacitor.

22. The process of claim 21 further including:

using charge limiting circuitry when applying the first reset signal, to prevent excessive charging of the integrating capacitor.

23. The process of claim 17 further including:

interrupting power to the operational amplifier substantially simultaneously with applying the first reset signal.

24. The process of Claim 17 further including:

setting a substantially stable second threshold voltage to determine a second and opposite end of the operating range wherein the condition-monitoring voltage, when in the operating range during integration, is moved toward the first threshold voltage and away from the second threshold voltage;

comparing the condition-monitoring voltage with the second threshold voltage; and

in response to detecting movement of the condition-monitoring voltage beyond the second threshold voltage and out of the operating range, applying a second reset signal to the feedback loop to drive the condition-monitoring voltage in the first direction to a point within the operating range for further integration of the electrical current.

25. The process of claim 24 wherein:

the condition-monitoring voltage when in the operating range during integration is higher than the first threshold voltage and lower than the second threshold voltage, and is reduced during integration.

26. The process of claim 25 further including:

alternatively applying a substantially stable high voltage and a substantially stable low voltage to the feedback loop; and

wherein said applying the first reset signal comprises switching from the low voltage to the high voltage to rapidly charge the integrating capacitor, and said applying the second reset signal comprises switching from the high voltage to the low voltage to rapidly discharge the integrating capacitor.

27. The process of Claim 24 wherein:

each application of the first reset signal and each application of the second reset signal are performed in rapid succession within a reset cycle, and consecutive reset cycles alternate with consecutive episodes of integrating the electrical current.

28. The process of claim 27 further including:

generating data for characterizing the electrical current based on said integrator output, identifying certain segments of the data corresponding to the reset cycles, and selectively ignoring said certain data segments when characterizing the electrical current.

29. An integrating electrometer and rapid reset circuit, including:

an operational amplifier with an integrator input for receiving an incoming electrical current, an integrator output for generating an integrator output voltage that changes in a predetermined first direction and at a rate determined by a level of the incoming current, and a feedback loop including an integrating capacitor;

a first circuit for detecting a voltage along the feedback loop to provide a condition-monitoring voltage that undergoes changes in response to the incoming current consistent with the changes to the integrator output voltage;

a voltage source for setting a substantially stable first threshold voltage, thereby to determine a first end of an operating range over which the incoming current is integrated;

a second circuit for receiving the condition-monitoring voltage and the first threshold voltage, detecting movement of the condition-monitoring voltage in the first direction beyond the first threshold voltage and out of the operating range, and in response to detecting said movement, applying a first reset signal to the feedback loop to drive the condition-monitoring voltage in a second and opposite direction to a point within the operating range for further integration of the incoming current.

30. The circuit of claim 29 wherein:

the second circuit further is adapted to detect movement of the condition-monitoring voltage in the second direction beyond the first threshold voltage and into the operating range, and to stop applying the first reset signal to the feedback loop in response to detecting said movement in the second direction.

31. The circuit of claim 29 wherein:

the first circuit includes an RC network for interposing a time delay between a given change in the integrator output voltage and the condition-monitoring voltage received at the second circuit.

32. The circuit of claim 29 further including:

a voltage source for setting a substantially stable second threshold voltage, thereby to determine a second, opposite end of the operating range; and

a third circuit for receiving the condition-monitoring voltage and the second threshold voltage, detecting movement of the condition-monitoring voltage in the second direction beyond the second threshold voltage out of the operating range, and in response to sensing said movement in the second direction, applying a second reset signal to the feedback loop to drive the condition monitoring voltage in the first direction to a point within the operating range for further integration of the incoming current.

33. The circuit of claim 32 wherein:

the operational amplifier, the first circuit, the second circuit and the third circuit are disposed on a single integrated circuit chip.

34. The circuit of claim 32 wherein:

the condition-monitoring voltage when in the operating range is higher than the first threshold voltage and lower than the second threshold voltage, and is reduced during integration of the incoming current.

35. The circuit of claim 34 wherein:

the second circuit is adapted to alternatively generate a substantially stable high voltage and a substantially stable low voltage, and applying the first reset signal to the feedback loop

consists essentially of switching from the low voltage to the high voltage to rapidly charge the integrating capacitor.

36. The circuit of claim 35 wherein:

the third circuit is adapted to alternatively generate a substantially constant high voltage and a substantially constant low voltage, and applying the second reset signal to the feedback loop consists essentially of switching from the high voltage to the low voltage to rapidly discharge the integrating capacitor.

37. The circuit of claim 29 wherein:

the condition-monitoring voltage, when in the operating range, is higher than the first threshold voltage and is reduced during integration of the incoming current.

38. The circuit of claim 37 wherein:

the second circuit is adapted to alternatively generate a substantially stable high voltage and a substantially stable low voltage for application to the feedback loop, and applying the first reset signal consists essentially of switching from the low voltage to the high voltage to rapidly charge the integrating capacitor.

39. The circuit of claim 38 further including:

a diode located between the operational amplifier and the integrating capacitor, oriented to provide a current flow between the operational amplifier and the integrating capacitor to bypass a power input terminal of the operational amplifier during charging of the integrating capacitor.

40. The circuit of claim 38 further including:

a power control circuit coupled to receive the first reset signal from the second circuit, and further coupled to provide its output to a power input terminal of said operational amplifier to provide power to the operational amplifier;

wherein the power control circuit is adapted to generate as said output a substantially stable high voltage during integration, and to switch from the high voltage to a low voltage in response to receiving the high voltage from the second circuit, to substantially shut off power to the operational amplifier.

41. The circuit of claim 40 further including:

a limiting circuit coupled between the second circuit and the feedback loop, to prevent excess charging of the integrating capacitor.

42. The circuit of claim 29 further including:

a differentiating amplifier coupled to receive the integrator output voltage, adapted to differentiate the integrator output voltage to provide a differentiator output that increases and decreases with the incoming electrical current.

43. An instrument for characterizing aerosols subject to fluctuation in particle concentration, including:

a conduit for guiding an aerosol in a substantially non-turbulent flow at a substantially constant volumetric flow rate toward and along a particle measuring region, wherein the aerosol consists essentially of a polydisperse suspension of particles in a gaseous medium;

a first electrode configuration disposed along the measuring region;

a second electrode configuration including at least one collector electrode, electrically isolated from the first electrode configuration, and spaced apart from the first electrode configuration to allow the aerosol to flow between the first and second electrode configurations as it moves through the measuring region;

a voltage source for selectively biasing the first electrode configuration relative to the second electrode configuration to generate an electrical field along the measuring region, whereby particles of the aerosol, when carrying a charge of a selected polarity and when carried by the gaseous medium along the measuring region, are attracted toward the second electrode configuration to cause a portion of the particles to collect at the at least one collector electrode; and

a current measuring device coupled to the at least one collector electrode for receiving an incoming electrical current from the at least one collector electrode generated by said collecting of the charged particles, said measuring device including an integrating component for integrating the incoming electrical current to produce an output voltage corresponding to said current, and a reset component for selecting a range of output voltages over which the current is integrated, and for resetting the integrating component in response to movement of the output

voltage outside the selected range, to reposition the output voltage within the operating range for further integration of the incoming current.

44. The instrument of claim 43 wherein:

the first electrode configuration is centered on a longitudinal axis, and the second electrode configuration is annular, surrounds the first electrode configuration, and is concentric about the longitudinal axis.

45. The instrument of claim 44 wherein:

the first electrode configuration comprises a plurality of electrode segments spaced apart from one another in the longitudinal direction, electrically isolated from one another, and electrically biased to different voltage levels.

46. The instrument of claim 44 wherein:

the at least one collector electrode includes a plurality of annular collector electrodes serially arranged in the longitudinal direction and electrically isolated from one another; and

the current measuring device comprises a plurality of current measuring devices, each coupled to an associated one of the collector electrodes to receive incoming current from its associated collector electrode, and adapted to generate an analog signal in response to the incoming current.

47. The instrument of claim 46 further including:

processing circuitry for receiving the analog signals from the measuring devices, and for generating a particle concentration indication associated with each analog signal.

48. The instrument of claim 47 wherein:

the processing circuitry includes A/D circuitry for generating a digital value based on each analog signal, and processing means for generating each of the particle concentration indications based on its associated digital value.

49. The instrument of claim 48 wherein:

the processing means are adapted to determine a fractional share of a total particle concentration represented by a selected one of the collector electrodes, and to apply the

fractional share to the particle concentration indication of the collector electrode adjacent and upstream of the selected collector electrode, to correct the upstream concentration indication of the upstream electrode for image charging effects.

50. The instrument of claim 48 wherein:

the processing means include a plurality of different time delays applied selectively to the particle concentration indications associated with upstream collector electrodes, to synchronize the particle concentration indications associated with a given volume of the aerosol as it travels through the measuring region.

51. The instrument of claim 43 wherein:

the integrating component comprises an operational amplifier having a feedback loop, and an integrating capacitor along the feedback loop.

52. The instrument of claim 51 wherein:

the integrating capacitor is configured to gradually discharge as the incoming current is integrated, thereby gradually reducing the integrator output voltage.

53. The instrument of claim 51 wherein:

the reset component includes means for setting a first threshold voltage to determine one end of an operating range for integrating the incoming current, and a first comparator for comparing a condition-monitoring voltage along the feedback loop with the first threshold voltage, wherein said first comparator is adapted to apply a first reset signal to the feedback loop in response to detecting movement of the condition-monitoring voltage in a first direction beyond the first threshold voltage and out of the operating range, thereby to drive the condition-monitoring voltage in a second and opposite direction back to a point within the operating range for further indication of the incoming current.

54. The instrument of claim 53 wherein:

the first comparator further is adapted to detect movement of the condition-monitoring voltage in the second direction beyond the first threshold voltage and back into the operating range after application of the first reset signal, and to terminate the application of the first reset signal in response to detecting said movement in the second direction.

55. The instrument of claim 53 wherein:

the reset component further includes means for setting a second threshold voltage to determine a second and opposite end of the operating range, and a second comparator coupled to receive the condition-monitoring voltage and the second threshold voltage, for applying a second reset signal to the feedback loop in response to detecting movement of the condition-monitoring voltage in the second direction beyond the second threshold voltage out of the operating range, thereby to drive the condition-monitoring voltage in the first direction back to a point within the operating range for further integration of the incoming current.

56. The circuit of claim 55 wherein:

each of the first and second comparators is adapted to alternatively generate a substantially stable high voltage and a substantially stable low voltage;

the first comparator applies the first reset signal to the feedback loop by switching from the low voltage to the high voltage to rapidly charge the integrating capacitor; and

the second comparator applies the second reset signal to the feedback loop by switching from the high voltage to the low voltage to rapidly discharge the integrating capacitor.

57. The instrument of claim 43 further including:

a charging device disposed in the conduit upstream of the measuring region, for applying a charge of said selected polarity to the particles as the aerosol approaches the measuring region.

58. The instrument of claim 57 wherein:

the charging device includes a corona discharge element.

59. The instrument of claim 47 wherein:

the first electrode configuration is biased to a positive voltage, and each of the collector electrodes is maintained at ground.

60. The instrument of claim 45 wherein:

said different voltage levels are positive, and increase in the downstream direction.

61. A process for characterizing aerosols subject to fluctuations in particle concentration, including:

guiding the aerosol toward and along a particle measuring region in a substantially non-turbulent flow, in an axial direction, and at a substantially steady volumetric flow rate;

disposing an axially extending collector electrode configuration in the measuring region;

generating an electrical field in the measuring region to cause the particles that carry a charge of a selected polarity to move toward the collecting electrode configuration as the aerosol flows axially through the measuring region, and using at least one collector electrode of the collector electrode configuration to collect a portion of the charged particles;

sensing an electrical current along an electrical conductor coupled to the at least one collector electrode;

using a circuit including an integrating capacitor to generate condition-monitoring output signal that changes in a first direction responsive to the electrical current, and at a rate proportional to a level of the electrical current; and

setting a first threshold to determine a first end of an operating range over which the electrical current is integrated, comparing the output signal to the first threshold as the output signal is moved in a first direction while in the operating range during said integration, and detecting movement of the output signal in the first direction beyond the first threshold and out of the operating range; and

in response to said detection, applying a first reset signal to the integrating circuit near the integrating capacitor, to drive the output signal in a second direction opposite the first direction, back into the operating range for further integration of the electrical current.